

Regional HOT Lanes Network Feasibility Study

APPENDIX F

CORRIDOR ANALYSIS: US-101 FROM LUCKY DRIVE TO NORTH SAN PEDRO ROAD

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and

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Introduction

This memorandum applies a project development approach and set of corresponding design principles that were developed in Phase 3 Tasks 22.1 and 22.2 to a specific segment of US-101 in Marin County from Lucky Drive to North San Pedro Road. Similar memoranda are being prepared for other selected corridors in the proposed MTC HOT lane network. These memoranda are intended both to advance the plans for HOT lane development in the corridors under study and to provide a basis for drawing conclusions about the likely impacts, costs, and design issues required to convert or develop HOT lanes in other network corridors not under detailed study.

At the direction of MTC and the Project Steering Committee, this analysis covered two approaches to developing HOT lanes in the corridor, the “Basic Approach”¹ and the “Revised Full Featured Approach”². The primary difference between the two is that in constrained situations the Basic Approach allows for sub-standard inside shoulders and a reduction of lane widths from the 12-foot standard to 11 feet in order to make the added lane fit within the available right-of-way, while the Revised Full Featured Approach would maintain Caltrans District 4 preferred design guidance. Under exceptionally constrained conditions where freeway widening is infeasible due to cost or environmental reasons then the outside shoulder may also fall below Caltrans’ 10-foot standard width.

This memorandum begins with a description of existing conditions in the corridor, followed by sections describing the proposed typical HOT lane sections and access and egress points, and closes with a section describing the study team's findings regarding development of HOT lanes in this corridor.

¹ This is derived from the “Rapid Delivery Approach” in Phase 2b of this study

² This is derived from the approach used in Phase 2 of this study, which assumed full Caltrans District 4 preferred design guidance

Description of the Existing Corridor

This corridor segment is approximately five miles long, running from Lucky Drive to North San Pedro Road interchange. It is located in a medium-density suburban area serving the towns of San Rafael, Larkspur, and Corte Madera (see Figure 1). This section passes through two hills or ridges north and south of central San Rafael and includes a major bridge over Corte Madera Creek. There is one major interchange (with I-580 in San Rafael) and five minor interchanges³.

The section of US-101 under study generally consists of four portions that can be described south-to-north as:

- From Lucky Drive to Francisco Boulevard the southbound side of the freeway has three general purpose lanes plus one HOV lane, while the northbound direction has four general purpose lanes. This section includes the bridge over Corte Madera Creek and the section through Cal Park Hill.
- From Francisco Boulevard to Mission Avenue the freeway is on parallel viaducts at different profiles over a slough and the San Rafael local street grid. The viaducts are approximately 25-feet apart and are of different ages and reflect different structural designs. There are three general purpose lanes in each direction.
- From Mission Avenue to Lincoln Avenue the freeway profile is on embankment and then at-grade as it passes through a gap in Puerto Suello Hill. There are three general purpose lanes in the southbound direction and four general purpose lanes in the northbound direction, which runs uphill.
- From Lincoln Avenue to North San Pedro Road there are four general purpose lanes in both directions with auxiliary lanes in some places. Bicycles are permitted from Lincoln Avenue to North San Pedro Road.

This portion of US-101 carries heavy volumes of commuter traffic during peak hours. Daily traffic volumes vary from 134,000 to 187,000 AADT. It is signed at 55 MPH.

³ At Sir Francis Drake Boulevard, 2nd Street, Mission Avenue, Lincoln Avenue, and North San Pedro Road

Other Projects in Vicinity

There are four projects relevant US-101 in this area:

- The Transportation Authority of Marin (TAM) is sponsoring the Gap Closure Project to add an HOV lane in each direction to connect the existing HOV lane that terminates south of Anderson Drive with the HOV lanes that extend north from North San Pedro Road. The project will make use of space currently available on the inside shoulders of the freeway and also space made available by acquiring a row of houses on the southbound side of the freeway near Linden Lane. Construction work has already begun on this project.
- The Hwy 101 Greenbrae/Twin Cities Corridor Improvement Project involves a variety of improvements on US-101 and the local street network including new auxiliary lanes, re-configuring the Tamalpais interchange, and adding new northbound ramps at Wornum Way. This is a multi-component project that is currently in the PAED stage and expected to be implemented in stages.
- The Sonoma Marin Area Rapid Transit (SMART) Project was approved by voters in a November 2008 ballot measure. The project will take a disused railroad alignment running parallel to US-101 on the southbound side and create a commuter rail service as well as a two-way bicycle path. This project will be adjacent to US-101 in the Puerto Suello Hill area.
- The freeway connector between westbound I-580 and northbound US-101 is being widened to add a second lane. This project is currently under construction.

HOT Lanes Proposal – Mainline

There is or soon will be an HOV lane in each direction along the study section, therefore the mainline of the HOT facility (the lane and buffer, not including ingress and egress points) will be developed by adding a 2-foot buffer to the planned HOV lanes. The impact of adding a buffer varies by section along the freeway:

- In the Cal Park Hill section, the Gap Closure Project will have 2-foot inside shoulders, 11-foot inside lanes including the HOV lane, 12-foot outside lanes

including the northbound climbing lane, and 10-foot outside shoulders (see Figure 2). In other words, every component of a reduced design is already at the minimum prescribed width. Outside of the roadway there is a retaining wall on the southbound side and a steep cut on the northbound side (see Figure 3). This type of section extends for approximately 1100 feet.

The Basic Approach to conversion to HOT operation would create the 2-foot buffer by narrowing the inside 12-foot lane to 11 feet and reducing the outside shoulder to 9 feet. While a substandard outside shoulder is never a desirable condition, the fact that the section includes a climbing lane indicates that speeds are lower than typical freeway conditions (it is signed for 55 MPH). Moreover, there are other sections of US-101 that already have or are planned to have sub-standard shoulders, such as the viaducts through central San Rafael. If funds permit it would be desirable to provide a widened section of outside shoulder for use as an emergency pull-out refuge.

To achieve the Revised Full Featured Approach in this section, the freeway would need to be widened by twelve feet⁴ into the hill face on the northbound side and building a retaining wall. This would appear to create right-of-way issues on either end of the cut. The median barrier would then be shifted 2 feet eastward and the pavement re-striped to add a 2-foot buffer in each direction between the HOT lane and the adjacent inside lane.

- In the viaduct section the Gap Closure Project will have three 12-foot lanes in each direction plus an 11-foot HOV lane (see Figure 5). In the southbound direction there is an 8-foot inside shoulder that could be narrowed to 5 feet to allow create space for a 2-foot buffer and to widen the HOV/HOT lane to 12 feet.

The northbound viaduct does not have shoulder space which can be used to create a buffer; in fact, the outside shoulders will be narrowed to 8 feet as part of the Gap Closure Project (see Figure 6). Instead, for the Basic Approach two inside 12-foot lanes should be narrowed to 11-feet to make 2 feet of width available for the buffer. This will only be necessary for the length of the viaduct.

⁴ This includes two feet for a buffer, 1 foot to bring the 11-foot HOV lane to the 12-foot standard and three feet to bring the 2-foot inside shoulder to the 5-foot standard for a total of six feet of additional width per direction.

For the Revised Full Featured Approach, the northbound viaduct would need to be widened by 8 feet. The additional space thus created would allow for:

- The planned 8-ft outside shoulder to be widened to the 10-ft standard
 - The planned 2-ft inside shoulder to be widened to the standard 5-ft
 - The planned 11-ft HOV lane to be widened to the standard 12-ft
 - And a 2-ft buffer to be created between the HOT lane and the adjacent general purpose lane.
- In the Puerto Suello section south of Lincoln Avenue, the Gap Closure Project includes 12-foot outside lanes, 12-foot inside lanes (3 northbound, 2 southbound), an 11-foot HOV lane, 2-foot inside shoulders and 10-foot outside shoulders (see Figure 7). The section is constrained by a sound wall on the northbound side and the SMART Project on the southbound side. For this section the 2-foot buffer should be created by narrowing two of the inside lanes to 11-feet.
 - In the section north of Lincoln Avenue the Gap Closure Project plans to provide 12-foot outside lanes and have 11-foot inside lanes and HOV lanes (see Figure 8). The inside shoulders will be 2 feet, and the outside shoulder will vary from 2 feet to 10 feet. Outside of the freeway the site is constrained by the SMART Project on the southbound side and a portion of Puerto Suello Hill on the northbound side (see Figure 9).

The Basic Approach for this section of the freeway is to create space for the 2-foot buffer by narrowing the outside shoulder where possible. Where the outside shoulder is already 2-feet then the 12-foot lanes would need to be narrowed to 11-feet.

For the Revised Full Featured Approach the freeway would be widened by cutting 4 feet into the hill face on the northbound side and building a retaining wall. The median barrier would then be shifted 2 feet eastward and the pavement re-striped to add a 2-foot buffer between the HOT lane and the adjacent inside lane.

The approaches described above would allow for conversion of the planned HOV lane to a HOT lane over the entire corridor with the exception of the Lincoln Avenue undercrossing. The undercrossing takes the form of a “dip” with the elevation of Lincoln Avenue being higher on either side of the freeway than it is underneath (see Figure 10). The Gap Closure Project is widening the bridge just enough to accommodate 12-foot outside lanes, 11-foot inside lanes, and 10-foot outside shoulders (see Figure 11). The bridge cannot be widened a further 2 feet in the near-term to create space for the buffer because it would entail extending Lincoln Avenue’s “dip”, which is constrained on the west side by a tunnel for the SMART Project and on the east side by a steep hillside. A reconstruction of this bridge to meet design standards could be a future enhancement. For the short length of this pinch point this study assumed that the outside shoulders could be reduced to 8 feet. As stated earlier, US-101 has substandard shoulders in several places in the San Rafael area and so this would not be new or unexpected to drivers using the road.

HOT Lanes Proposal – Ingress and Egress Points

The approach taken in this study is that the placement of ingress and egress points should be primarily demand-driven; that is, ingress points should be located at a convenient distance downstream of places where large volumes of traffic enter the freeway system and egress points should be located at a convenient distance upstream of places where large volumes of traffic leave the freeway system. Once the high-demand locations were identified, a design analysis was then performed to determine whether an ingress or egress point could fit within the physical constraints of the location. In the event that the point could not be accommodated, a further analysis was performed to determine whether it could be accommodated by shifting the ingress or egress point to a location near the optimal point. Alternate locations for ingress points were sought downstream of the optimal point while alternate sites for egress points were sought upstream, meaning in effect that traffic wishing to enter or leave the HOT lane would have a longer distance in which to weave across the general purpose lanes. If no alternative site could be found then consideration was given to dropping the proposed site with the assumption that potential users of the point would enter or exit the HOT lanes at other points in the corridor.

The assumed designs of the ingress and egress points are shown in Figures 12 and 13. These designs closely resemble the M-5 design found in Caltrans' *HOV Guidelines*⁵ as modified for the proposed access points for the Sunol Express Lane in Alameda and Santa Clara Counties. Caltrans also has specified a required minimum distance between an HOV access point and the nearest freeway ramps (see Figure 14) that were considered when determining the location of potential ingress and egress areas.

Figures 15 and 16 show the volumes of traffic entering and exiting US-101 at various points along the corridor⁶, and identifies the points originally selected to serve this demand. Because the study corridor was only five miles long, only two points were studied in each direction of travel. Our analysis of these points is summarized in below:

- Southbound Egress – The demand analysis suggested that this site be a little south of North San Pedro Road to serve traffic exiting the HOT lane to go to central San Rafael. However, this site would have required widening the Lincoln Avenue Bridge which, as discussed earlier, would have proven difficult. The site was therefore shifted further south to the vicinity where the Gap Closure Project had acquired new ROW through elimination of houses and a soundwall on the southbound side (see Figure 17).
- Southbound Ingress – This point was intended to serve southbound traffic entering from central San Rafael. However, this site is on Cal Park Hill and would require significant excavation and retaining walls (see Figure 3). No suitable alternate location could be found nearby. Further south is a bridge over Corte Madera Creek that would require expensive widening to accommodate an access point.

On the advice of TAM alternate sites were then sought south of the Corte Madera Creek, with the rationale being that such sites might also serve the large traffic flows to and from Sir Francis Drake Boulevard. An alternate location was found within the Tamalpais Interchange (see Figure 18). The existing southbound loop on-ramp would need to be replaced with a slip ramp in order to

⁵ Source: Caltrans *High-Occupancy Vehicle Guidelines for Planning, Design, and Operations*, August 2003

⁶ Source: Caltrans' *2007 Traffic Volumes Report*

free up space under the existing crossover bridge. This would be an interim solution until the entire interchange is rebuilt as last stage in the Greenbrae Project ten to fifteen years from now. The ingress point could then be incorporated into the design of the new interchange. An operational analysis would be needed to determine whether the bridge would require temporary widening to accommodate queues of left-turning vehicles.

If the Tamalpais Interchange site proves to be infeasible for some reason, it may be possible to shift the ingress point north of the interchange. However, in order to meet Caltrans' minimum distance requirements from nearby ramps the southbound auxiliary lane that is currently part of the Greenbrae Project would have to be eliminated.

- Northbound Egress - The purpose of this site is to serve traffic exiting the HOT lane to go to central San Rafael. Unfortunately this site proved infeasible due to the excavation that would be required as described earlier for the southbound ingress point. However, it appears to be possible to incorporate this egress point into the Tamalpais Interchange, as shown in Figure 18. This would enable it to also serve traffic exiting the HOT lane to go to Sir Francis Drake Boulevard.
- Northbound Ingress – This site is intended to serve traffic entering the freeway from central San Rafael and wishing to enter the HOT lanes. The original site would have required expensive excavation into Puerto Suello Hill and a retaining wall. A less expensive alternate site was found within the North San Pedro Interchange that would be only slightly less convenient for users.

This corridor was one in which the original target number of ingress and egress points can feasibly be accommodated, but only by being flexible regarding their locations. The final suggested locations for access points are shown in Figure 19 and 20.

Findings Regarding HOT Lane Development in this Corridor

Based on this analysis, the development of HOT lanes in this corridor appears to be feasible. However, there are physical constraints to be overcome in several locations and some sections will require either design exceptions or expensive modifications of

the freeway. There are two key lessons from this corridor that can be applied to other parts of the regional HOT lane network, which are:

- Some portions of the network, particularly older parts that have already been modified in the past, have very little surplus width available. Even minor changes such as adding a 2-foot buffer could potentially prove problematic.
- The placement of access points in highly constrained corridors may be driven by physical constraints rather than by demand. This means that drivers wishing to use the HOT lanes will sometimes have to use the mixed-flow lanes for longer distances than they would prefer. This represents a trade-off between small reductions in the benefits of the system versus potentially large reductions in the cost of developing the system.

The lessons learned in this part of US-101 may be useful for other sections, such as the Marin-Sonoma narrows area.

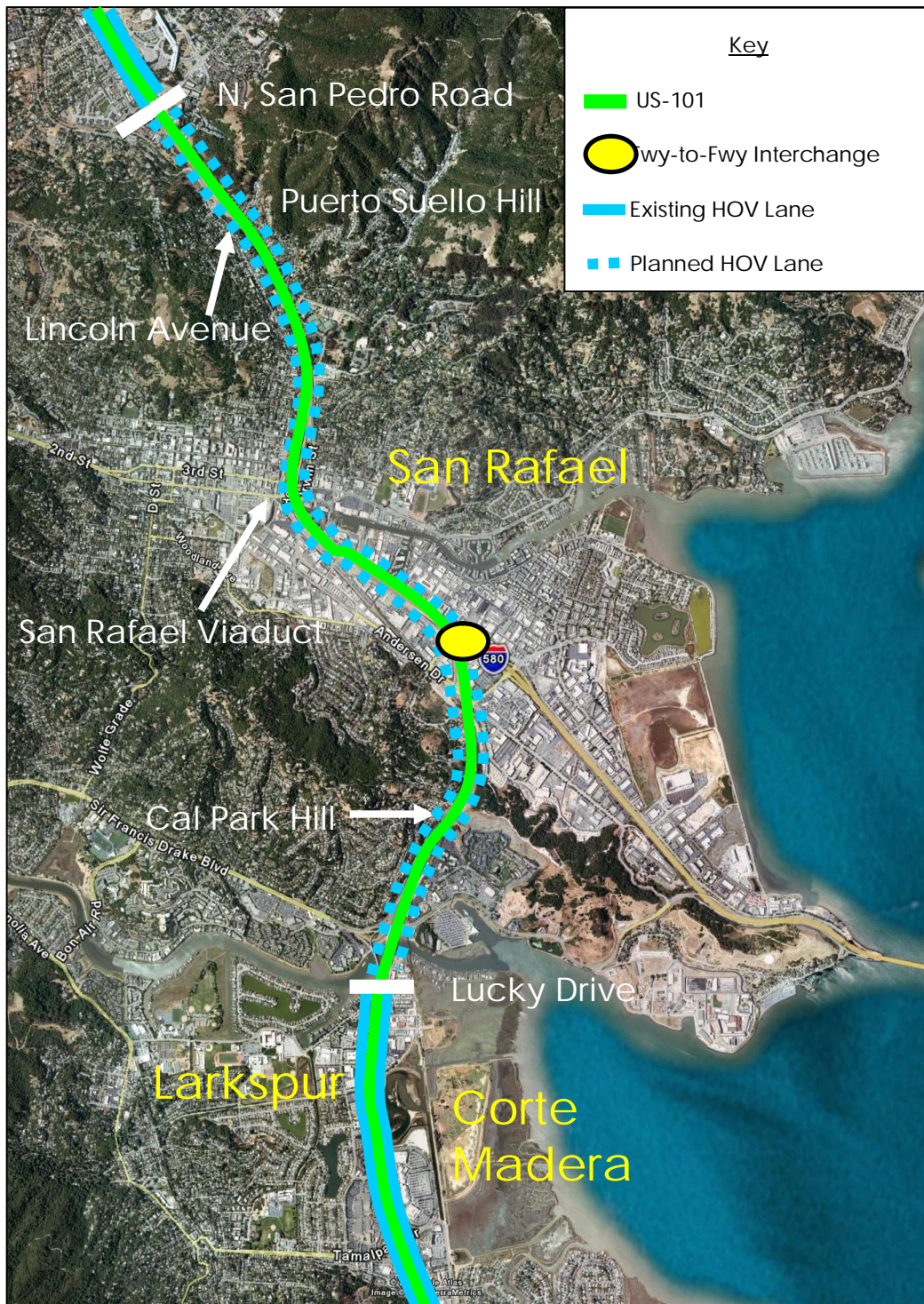
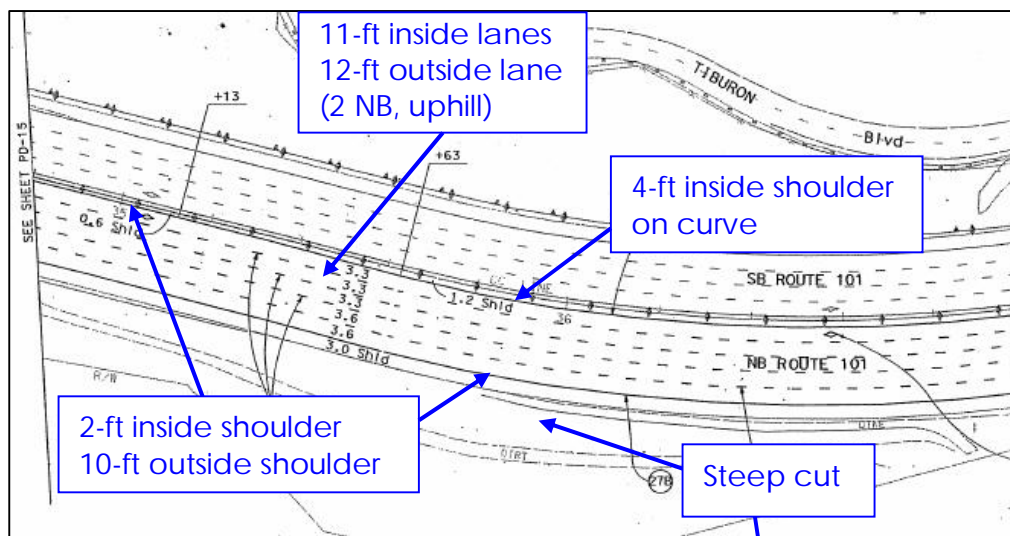
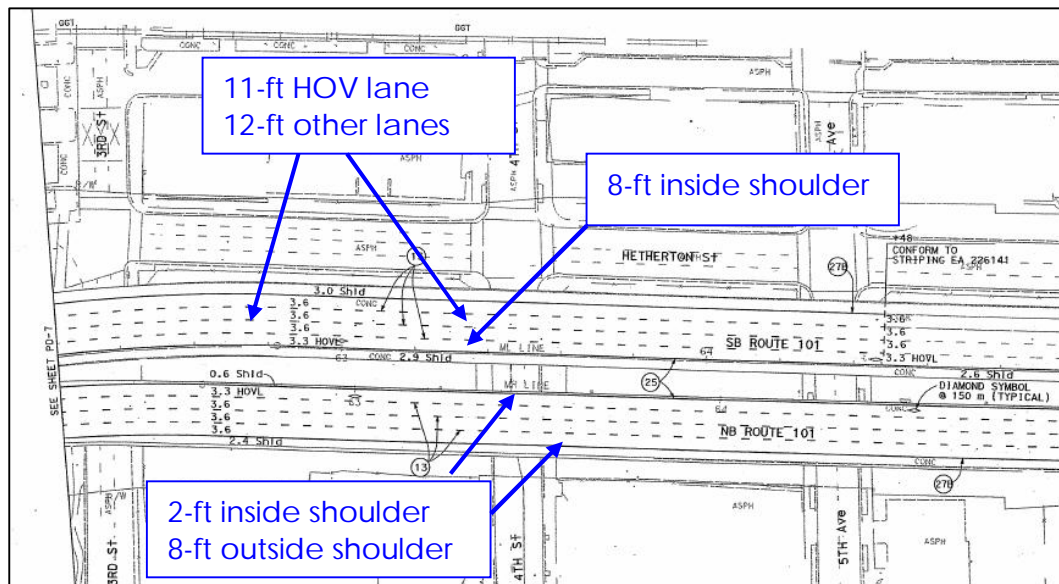


Figure 1: Study Corridor





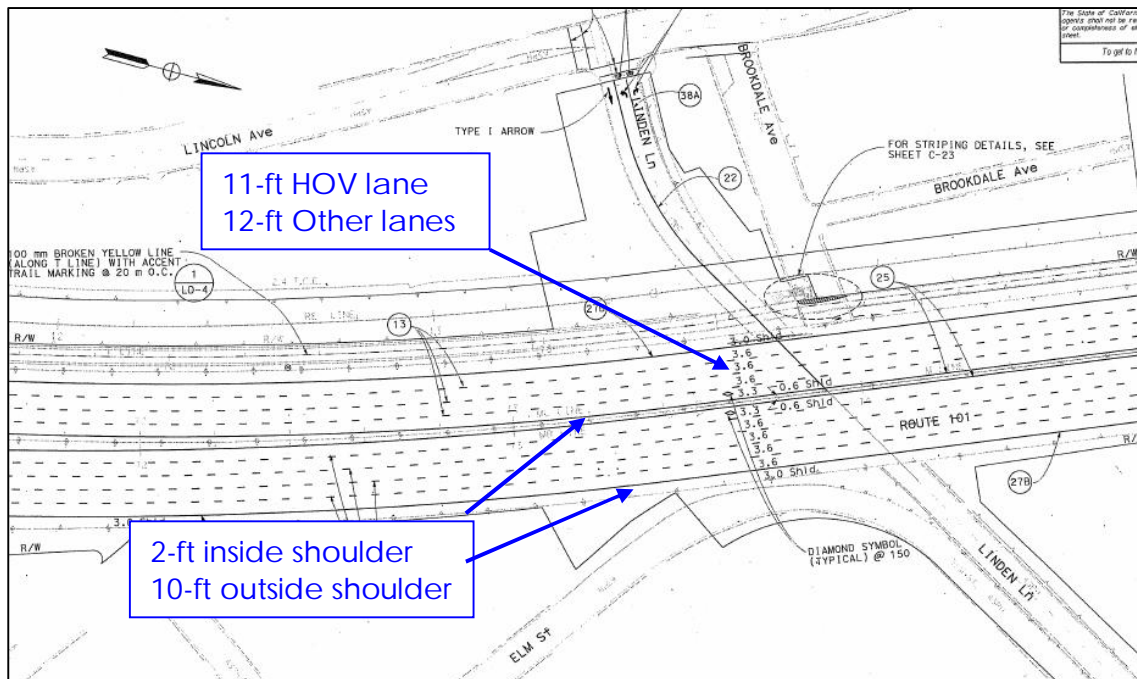


Figure 6: Portion of the Gap Closure Project Plan South of Lincoln Avenue



Figure 7: Street-Level View Section South of Lincoln Avenue

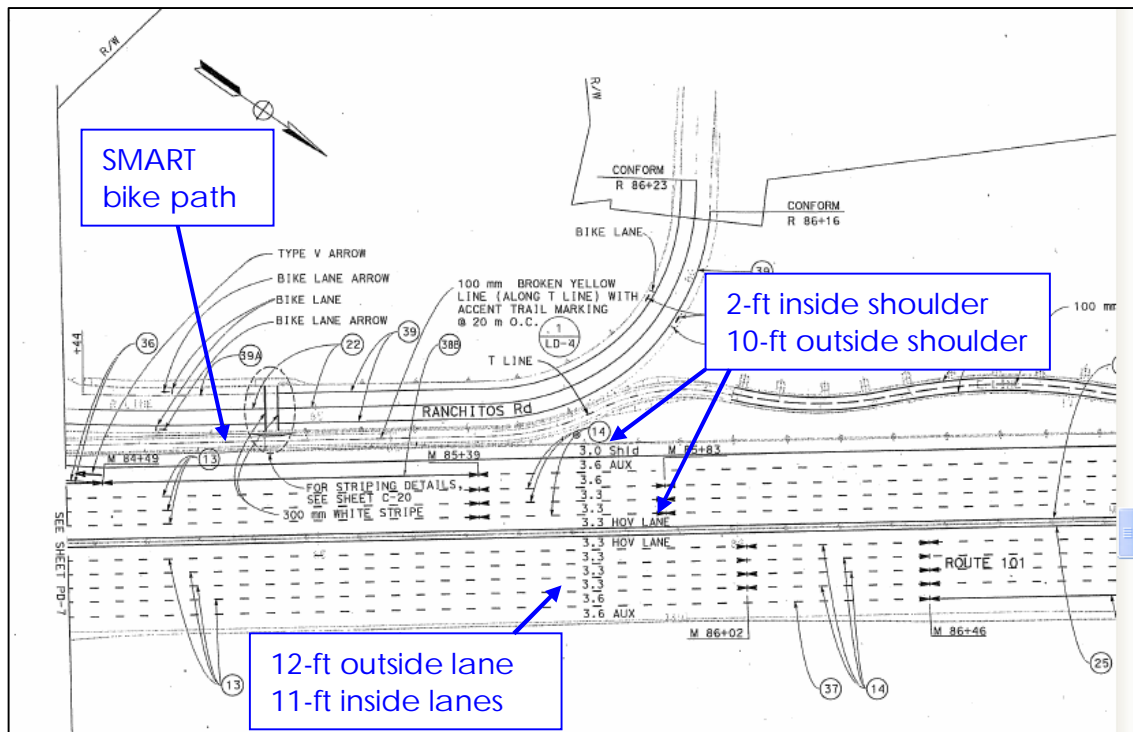


Figure 8: Portion of the Gap Closure Project Plan North of Lincoln Avenue



Figure 9: Street-Level View Section North of Lincoln Avenue



Figure 10: Widening of Lincoln Avenue Bridge

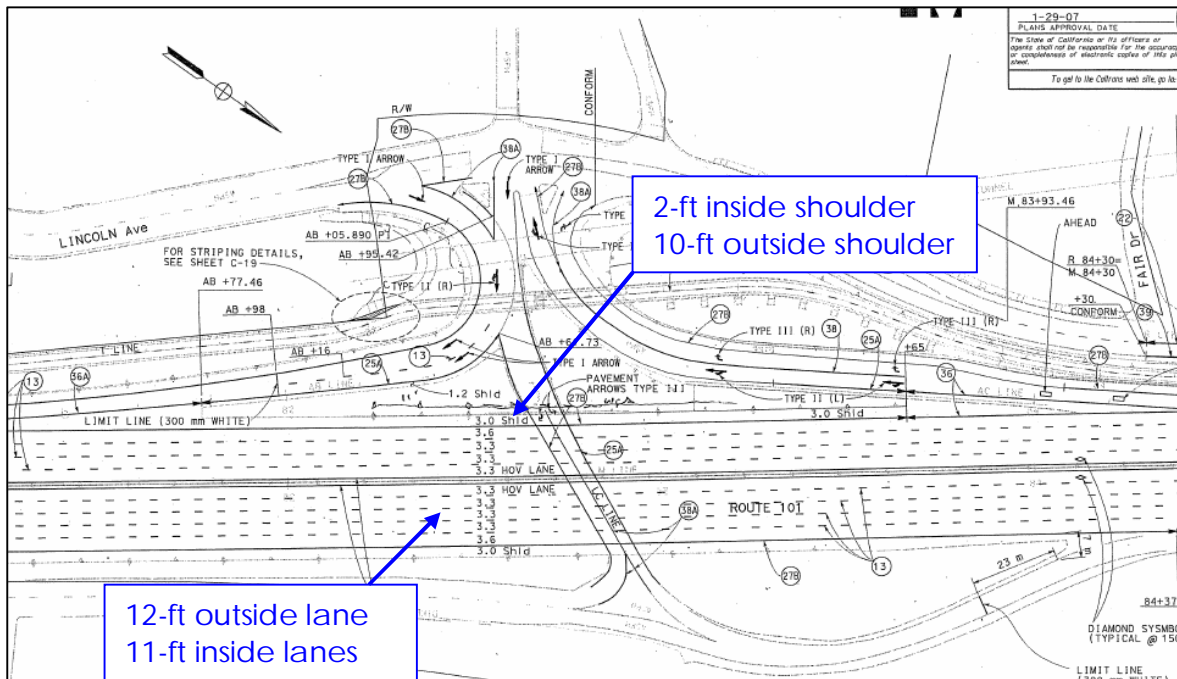


Figure 11: Portion of the Gap Closure Project Plan at the Lincoln Avenue Bridge

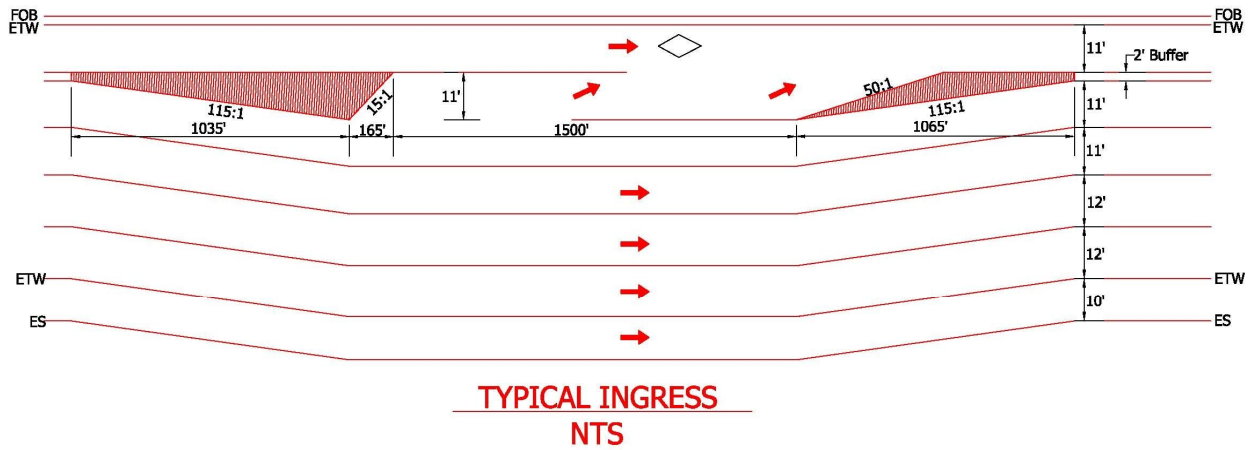


Figure 12: Typical Ingress Point for HOT Lane

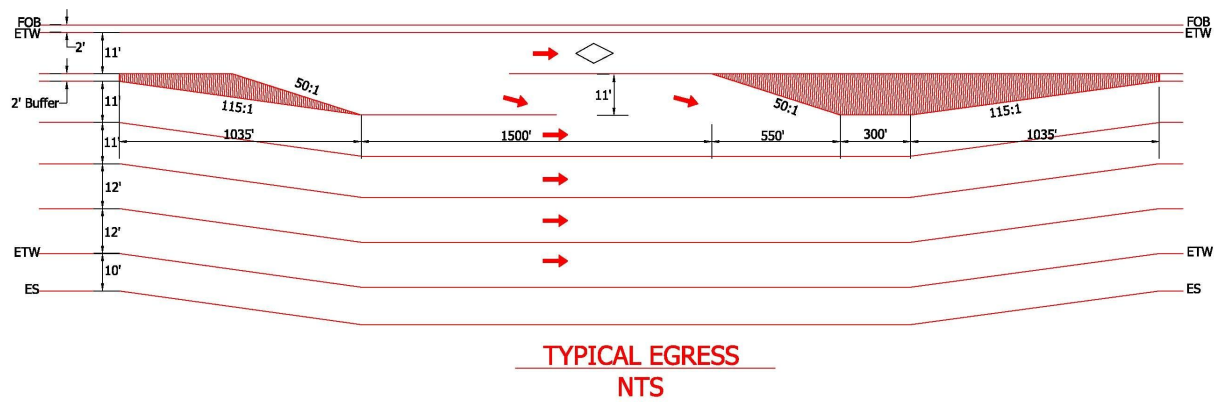
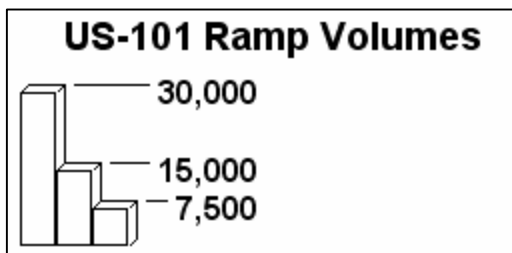
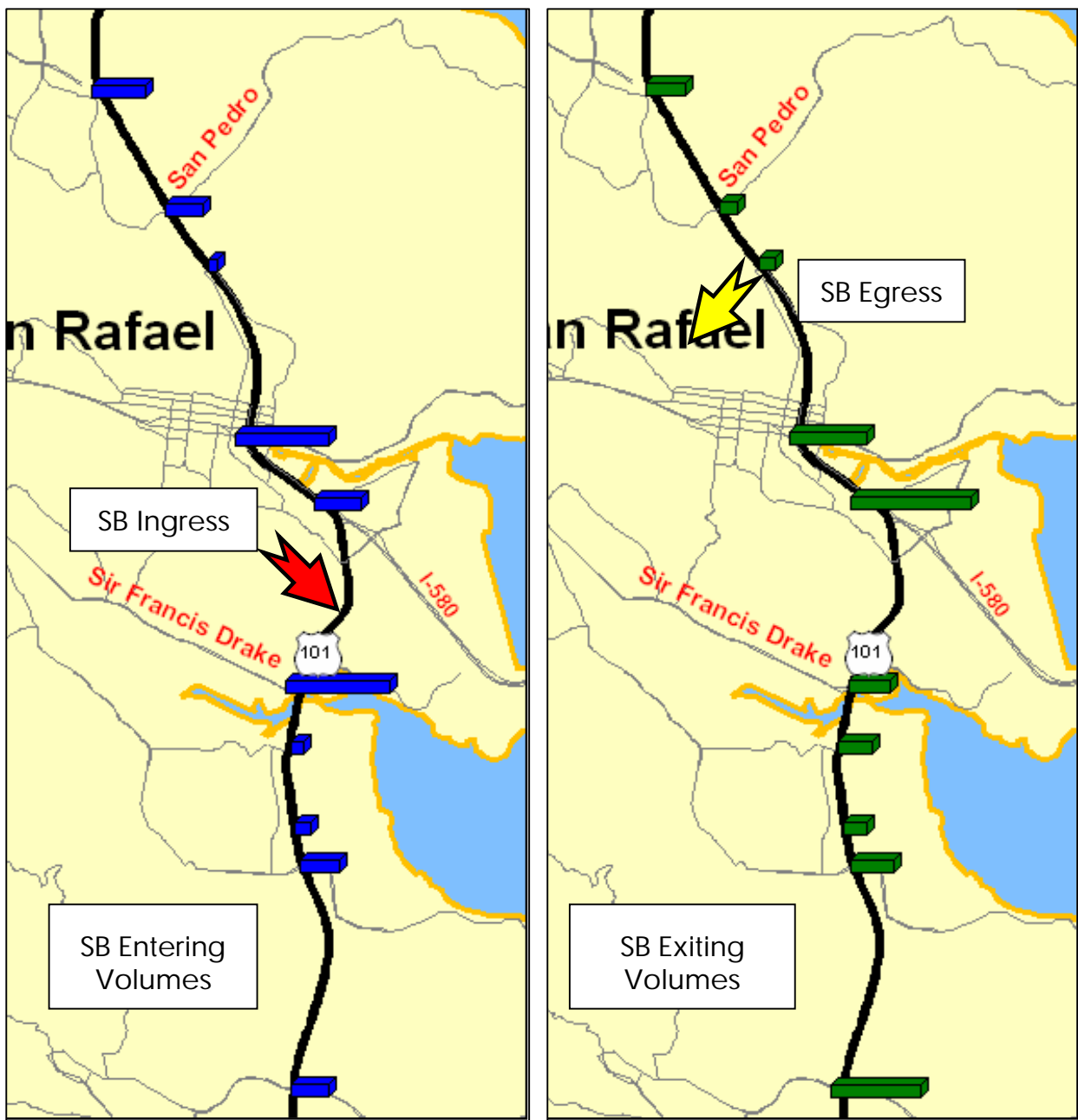


Figure 13: Typical Egress Point for HOT Lane





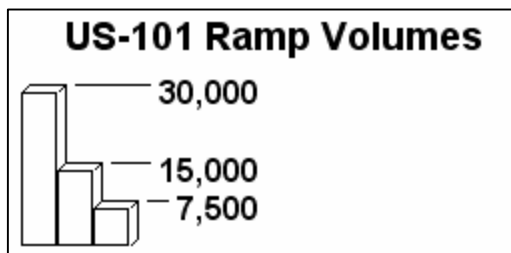
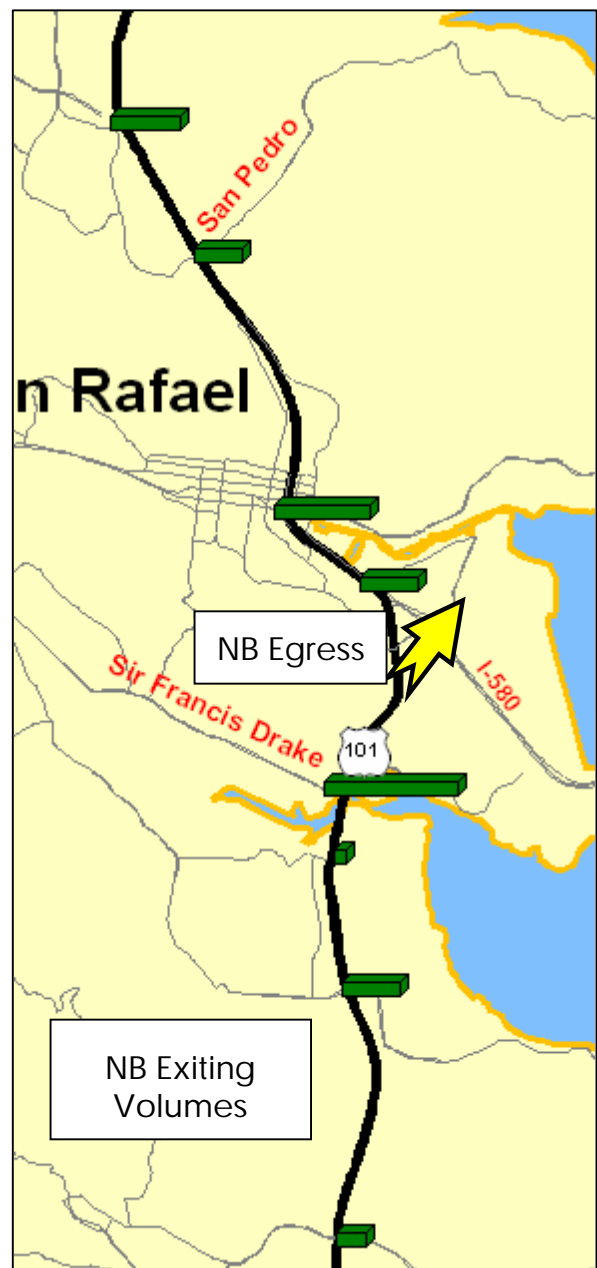
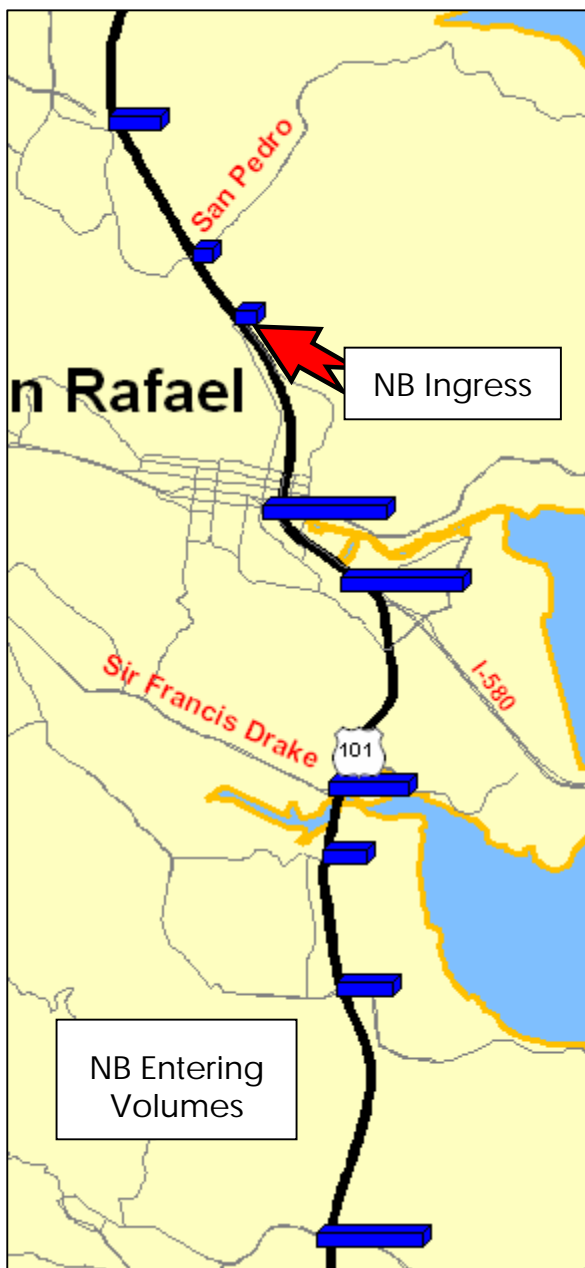
-  Potential Ingress Point
-  Potential Egress Point

Figure 15: Demand-Driven Southbound Ingress and Egress Locations





-  Potential Ingress Point
-  Potential Egress Point

Figure 16: Demand-Driven Northbound Ingress and Egress Locations

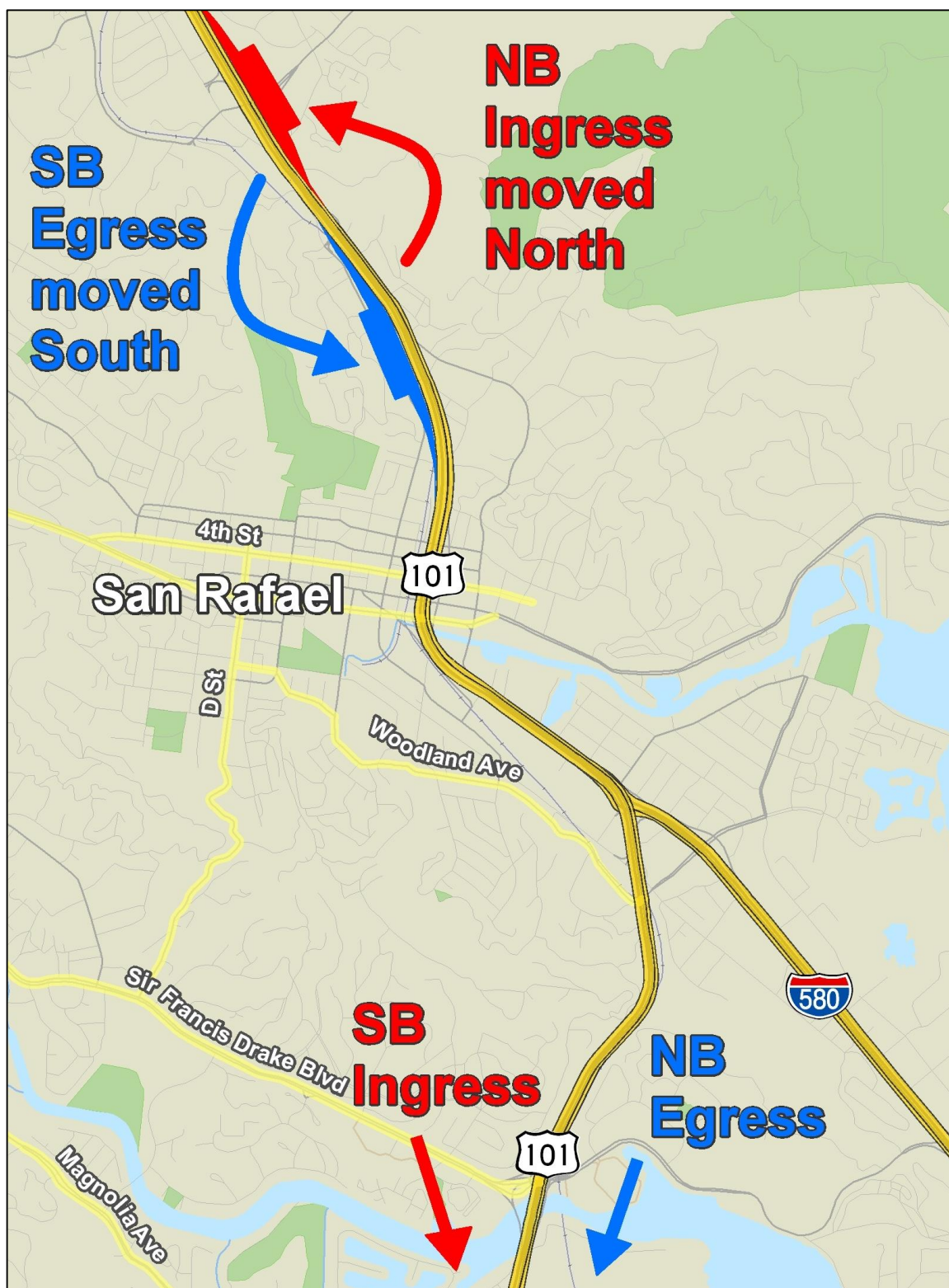


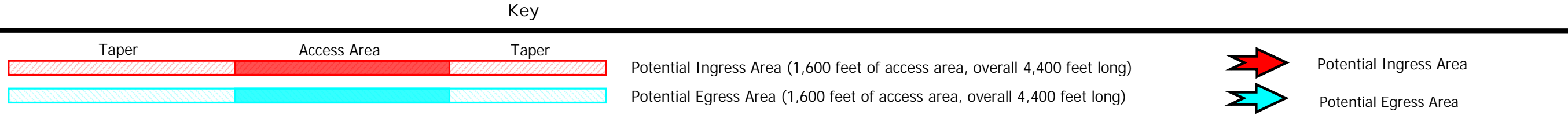
Figure 17: Adjustment of Ingress and Egress Locations



SB loop on-ramp to be replaced

Figure 18: Ingress and Egress Points within the Tamalpais Interchange

Figure 19: Recommended Access Points - US-101 (Tamalpais Dr to Lincoln Ave)





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